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[Title of the Invention] CDMA receiving circuit

[Abstract]

[Object] A CDMA receiving circuit is provided which is configured with a single MF circuit for reducing the circuit size and cost.

[Solving Means] At the time of initial capture of the spread code immediately after power is switched on, the MF6 determines the correlation with a short code for each base station supplied from a first spread code generator 3, and a decoder 4 acquires the spread code information. After that, based on the spread code information thus acquired, the spread code represented by the product of the base station long code and the user short code supplied from a second spread code generator is used by the MF6 to determine the correlation, so that a decision circuit 7 acquires a control signal/information signal.

[Scope of Claim for a Patent]

[Claim 1] A CDMA receiving circuit for receiving a transmission signal transmitted from a base station with each frame including spread code information having long code information and user short code information and data information having a control signal/information signal, the spread code information and the data information being time-divided, the spread code information being directly spread by the base station short code, the data information being directly spread by the spread code constituting the product of the long code and the user

short code described in the spread code information, characterized by one matched filter unit supplied with a switched spread code, in which at the time of initial capture of the spread code immediately after switching on power, the correlation between the received signal and the base station short code is determined to acquire the spread code information, and the correlation is determined between the received signal and the spread signal constituting the product of the long code and the user short coe based on the acquired spread code information thereby to acquire data information.

[Claim 2] A CDMA receiving circuit for receiving a transmission signal transmitted from a base station with each frame including spread code information having long code information and user short code information and data information having a control signal/information signal, the spread code information and the data information being time-divided, the spread code information being directly spread by the base station short code, the data information being directly spread by the spread code constituting the product of the long code and the user short code described in the spread code information, the CDMA receiving circuit comprising a receiving unit for down-converting the received signal from the carrier frequency band to the base band, a matched filter unit for acquiring the correlation between the received signal from the receiving unit and the input spread signal, a decision circuit for demodulating the data information from the output of the matched filter unit, a decoder for decoding the spread code information from the

output of the matched filter unit, a switch for switching the destination of the output of the matched filter unit between the decision circuit and the decoder, a first spread code generator for sending out a base station short code, a second spread code generator for sending out a spread code constituting the product of the long code and the user short code based on the input spread code information, and spread code switching means for selecting one of the two types of spread codes from the first spread code generator and the second spread code generator and supplying the choice to the matched filter unit for controlling the switching operation of the switch, characterized in that when the decoder extracts the spread code information from the output of the matched filter unit, applies it to the second spread code generator and outputs an instruction for switching the spread code to the spread code switching means, the spread code switching means selects the spread code from the second spread code generator, supplies it to the matched filter unit and controls the switch so the destination of the output of the matched filter unit is switched to the decoder.

[Claim 3] A CDMA receiving circuit according to claim 1 for receiving a signal of the data information transmitted by an adjacent base station using the same frequency and different long codes, characterized in that after complete initial capture of the spread code, the spread code information of the signal of the strongest average received power among the signals from other base stations than the one in communication is

received and stored, and the correlation is determined based on the stored spread code information when the cell is changed.

[Claim 4] A CDMA receiving circuit according to claim 2, characterized by the decoder for detecting the average received power of the signal received from each base station based on the output of the matched filter unit after initial capture, storing the averaged received power in the storage unit internal or external to the decoder together with the short code for each base station and, at the time of moving to another cell, outputting the base station short code of a base station having a large average received power stored in the storage unit as a spread code designating instruction to the first spread code generator, and the first spread code generator for sending out the the base station short code in accordance with the spread code designating instruction.

[Detailed Description of the Invention]

[0001]

[Technical Field Pertinent to the Invention] This invention relates to the CDMA (code division multiple access) receiving circuit used for the spectrum spread communication scheme for a radio communication system, or more in particular to a CDMA receiving circuit reduced in both circuit size and cost.

[0002]

[Prior Art] Generally in the CDMA, the use of a long code (long period spread code) is studied by various research organizations in order to reduce the interference from an adjacent cell (the area reached by the radio wave from the base

station) or whiten the echo having a large delay time, and the validity of the long code has been confirmed. (References: "Transmission Test for Mobile Radio Access Using Coherent Multicode DS-CDMA" by Adachi, Ohno, Sawabashi, et al., a technical research report [Antenna and Propagation], p. 13, Institute of Electronics, Information and Communication Engineers Technical and Research Report, Oct. 1995)

[0003] The length of the long code is generally 2^{33} or 2^{41} bits (See the aforementioned reference "Transmission Test for Mobile Radio Access Using Coherent Multicode DS-CDMA" and IS-95 (U.S. CDMA Cellular Standards), respectively). The initial synchronous capture of this code length is very difficult.

[0004] To cope with this problem, a synchronous capture scheme has been proposed in the reference "Long Code Synchronization for DS-CDMA Mobile Communication", by Nakamura, Umeda, Azuma, et al., NTT Mobile Communication Co., Ltd, Institute of Electronics, Information and Communication Engineers Assembly 1995, B-429 (hereinafter referred to as the reference 1). The scheme proposed in this reference indicates that the initial synchronous capture of the long code can be increased in speed.

[0005] In the system described in the reference mentioned above, there are three types of spread codes used in one cell, including the long code varied from one base station to another and not correlated between the base stations, a user short code varied from one user (mobile station) to another in a cell and not correlated with each other, and a base station short code assigned uniquely to each base station and having a pattern

predictable by a mobile station in advance.

[0006] First, the frame format of the transmission signal sent from each base station to each mobile station in a cell will be explained with reference to FIG. 6. FIG. 6 is a format diagram showing an example structure of the transmission signal frame transmitted from each base station to each mobile station in a cell.

[0007] Each frame of the transmission signal from the base station, as shown in FIG. 6, is configured with the long/short code information (spread code information) and the control signal/information signal (data information). The long/short code information specifically contains the long code information unique to each station and the user short code information usable in the particular cell, i.e. not used by other users.

[0008] The long code information and the short code information are the generating polynomials of the respective codes and the current or near-future contents of the shift register. FIG. 7 shows an example of the relationship between an example of the M series generating polynomial and the contents of the shift register.

[0009] Generally, the spread code is not limited to the M series, but, as shown in FIG. 7, can be generated by a linear feedback shift register including a shift register and an EOR (exclusive OR) circuit or a parallel arrangement thereof. Thus, it is possible to generate the long code and user short code transmitted from a base station currently or in the near future,

based on the contents of the generating polynomial and the shift register.

[0010] Also, the control signal/information signal represents the information (data information) transmitted individually from a base station to mobile stations; the control signal represents the information used for the control and monitor of the radio circuit and the call control such as an outgoing call, an incoming call or the end of speech; and the information signal represents the information directed to the user such as voices and data.

[0011] The long/short code information is transmitted by being spread with the base station short code providing a unique short code assigned to each base station, while the control signal/information signal is transmitted by being spread with the spread code obtained from the product of the user short code and the long code assigned to each mobile station individually from the base station.

[0012] The control signal/information signal are transmitted by being spread into as many different spread codes as the users existing in the same cell. The long/short code information, on the other hand, is spread by the same spread code (base station short code) to transmit the time-variant long code information and the user short code information.

[0013] Also, the frame timing is coincident between the long/short code information and the control signal/information signal transmitted from the base station 1 (BS1), and the long/short code information and the control signal/information

signal transmitted from the base station n (BSn). The transmission time (T1 in FIG. 6) of the long/short code information and the transmission time (T2 in FIG. 6) of the control signal/information signal are also common in the base stations.

[0014] Now, the CDMA receiving circuit shown in the references described above will be explained with reference to FIG. 8 showing the conventional CDMA receiving circuit. FIG. 8 is a block diagram showing the configuration of the conventional CDMA receiving circuit. The conventional CDMA receiving circuit comprises, as shown in FIG. 8, a RX1, an MF unit 2, a first spread code generator 3, a decoder 4", a second spread code generator 5, an MF unit 6" and a decision circuit 7.

[0015] Now, each part of the conventional CDMA receiving circuit will be explained specifically. The RX1 is a reactor (RX) for down-converting the frequency from the carrier frequency band to the baseband and corresponds to the receiving unit in the claims.

[0016] The MF unit 2 is a matched filter (MF) unit for acquiring the correlation between the baseband signal received and the spread code supplied from the first spread code generator 3, and outputs the correlation to decoder 4". By the way, the two input signals are both complex signals, and therefore the MF is provided for each of the real portion and the imaginary portion.

[0017] The first spread code generator 3 generates a base station short code constituting the spread signal unique to

the base station and outputs it to the MF unit 2. It is assumed here that the first spread code generator 3 is supplied with the base station short codes of all the base stations in advance.

[0018] Specifically, the first spread code generator 3 selects the base station short codes sequentially in frame periods from the base station short codes of a plurality of the base stations supplied in advance at the time of initial capture of the spread code immediately after power is switched on. The spread code of the selected base station short code is output to the MF unit 2, and upon receipt of a change stop instruction from the decoder 4", the first spread code generator 3 stops changing the base station short code and outputs the same spread code.

[0019] After that, upon receipt of a change start instruction from the decoder 4", the first spread code generator 3 again selects the base station short codes in frame periods sequentially, and outputs the spread code of the selected base station short code to the MF unit 2.

[0020] The decoder 4" acquires the long/short information from the correlation output from the MF unit 2, and outputs it as spread code information to the second spread code generator 5. Specifically, the decoder 4", upon acquisition of a high-level correlation value from the the correlation result output from the MF unit 2, outputs a change stop instruction to the first spread code generator 3 for stopping the change in the base station short code in order to specify the base station short code. Further, the baseband signal input from the RX1 is applied to the MF unit 2 for determining the

correlation by the specified base station short code, and the particular correlation result output is decoded. Thus, the long/short information including the long code information and the user short code information transmitted from the base station for each frame are acquired and output as the spread code information to the second spread code generator 5.

[0021] Subsequently, the power value of the correlation result output from the MF unit 2 is monitored, and if the hand-off or the like action is required as the power value decreases below the predetermined value or otherwise, a change start instruction is output to the first spread code generator 3 to restart the change of the base station short code.

[0022] The second spread code generator 5 is for outputting the spread code representing the product of the long code and the user short code to the MF 6" in order to acquire the control signal/information signal from the received data based on the spread code information supplied from the decoder 4".

[0023] The MF unit 6" is a matched filter (MF) unit for acquiring the correlation between the received baseband signal and the spread code supplied from the second spread code generator 5 and outputs the correlation to the decision circuit 7.

[0024] The decision circuit 7 is for demodulating the control signal/information signal from the correlation output from the MF unit 6".

[0025] Now, the operation of the conventional CDMA receiving circuit will be explained with reference to FIGS. 6 and 8. The conventional CDMA receiving circuit, upon receipt of a signal

having a format shown in FIG. 6 transmitted from the base station, down-converts the frequency from the carrier frequency band to the baseband by RX1 and acquires the baseband received signal. In this way, the correlation with the supplied spread code is acquired in the MF unit 2 and the MF unit 6".

[0026] At the time of initial capture of the spread signal immediately after power is switched on, it is unknown from which base station the received signal has been transmitted. Specifically, since the base station short code of the transmitting base station is not known, the first spread code generator 3 selects the base station short codes sequentially in frame periods from the predetermined base station short codes of the base stations, and outputs the spread code of the selected base short code to the MF unit 2.

[0027] In the MF unit 2, the correlation between the baseband received signal and the spread code supplied from the first spread code generator 3 is determined, and output to the decoder 4", where a high-level correlation is obtained from the correlation output result. Then, a change stop instruction is issued to the first spread code generator 3, thereby fixing (specifying) the spread signal (base station short code) output from the first spread code generator 3.

[0028] In the decoder 4", the long/short code information is decoded from the result of determining the correlation with the specified base station short code, so that the spread code information including the long code information and the user short code information is acquired and output to the second

spread code generator 5.

[0029] Based on the spread code information from the decoder 4", the second spread code generator 5 outputs the spread code representing the product of the long code and the user short code to the MF unit 6". The MF 6" determines the correlation between the spread code and the received baseband signal, so that the control signal/information signal is demodulated in the decision circuit 7.

[0030] As a result of the operation mentioned above, the spread code (the product of the long code and the user short code) used for transmission at the base station in a cell where the mobile station is located is subsequently coincident with the output of the second spread code generator 5 of the mobile station, thus terminating the initial synchronous capture of the spread signal.

[0031] In the conventional CDMA receiving circuit, the operation described above makes possible the acquisition of the code synchronization of the long code of which the initial synchronous capture is difficult.

[0032] Now, the hand-off operation of the conventional CDMA receiving circuit will be briefly explained. The hand-off is a function harboring the problem pointed out that the communication is temporarily interrupted by the switching of the connection in the conventional cellular telephone when the mobile station moves to an adjacent cell.

[0033] Specifically, assume an environment in which cells (BS2 to BSx, where x is the number of adjacent cells) adjacent to

the cell (BS1) in communication transmit the same information as in BS1 using a different spread code. The transmission is realized in such a manner that each mobile terminal receives and determines by switching and synthesizing the signal received from each cell according to the level thereof.

[0034] In the process, all the adjacent base stations use the same frequency in the CDMA system without switching the frequency between different cells. This is indicative of the absence of the instantaneous interruption of the received signal which otherwise might be caused by frequency switching.

[0035] At the time of hand-off, the conventional CDMA receiving circuit so operates that after complete initial capture described above, the decoder 4" monitors the power value of the correlation result output from the MF unit 2, and when the power value decreases below a preset value and the requirement of hand-off occurs, a change start instruction from the decoder 4" is output to the first spread code generator 3, which again selects the base station short codes sequentially in frame periods, and the spread code of the selected base station short code is output to the MF unit 2.

[0036] Subsequently, the base station short code of the destination base station for which a high-level correlation value is obtained is specified by the operation similar to the one for initial capture, and based on the decoded long/short code information, new spread code information is output to the second spread code generator 5, thereby accomplishing the hand-off operation.

[0037]

[Problem to be Solved by the Invention] In the conventional CDMA receiving circuit described above, however, a dedicated MF unit (the MF unit 2 in FIG. 8) is required for initial synchronous capture of the long code, with the result that a total of two MF units are required to be installed including the MF unit (the MF unit 6" in FIG. 8) for received signal decision. The MF unit generally includes a multiplicity of multiplier circuits and adder circuits and therefore the problem of a larger circuit size and cost is posed.

[0038] Also, in the conventional CDMA receiving circuit, the spread code of the destination base station is captured and the switching operation (hand-off) is performed similar to the that of the initial capture after the need arises for hand-off, and therefore the problem is that the hand-off cannot be smoothly carried out.

[0039] The present invention has been developed in view of the situation described above, and the object thereof is to provide a CDMA receiving circuit configured with a single MF unit, in which both the circuit size and the cost can be reduced while making a smooth hand-off possible at the same time.

[0040]

[Means for Solving the Problem] In order to solve the problems of the prior art mentioned above, according to claim 1 of the invention, there is provided a CDMA receiving circuit for receiving a transmission signal transmitted from a base station with each frame including spread code information having long

code information and user short code information and data information having a control signal/information signal, the spread code information and the data information being time-divided, the spread code information being directly spread by the base station short code, the data information being directly spread by the spread code constituting the product of the long code and the user short code described in the spread code information, characterized by one matched filter unit supplied with a switched spread code, in which at the time of initial capture of the spread code immediately after switching on power, the correlation between the received signal and the base station short code is determined to acquire the spread code information, and the correlation is determined between the received signal and the spread code constituting the product of the long code and the user short code based on the acquired spread code information thereby to acquire data information, thereby making it possible to configure the CDMA receiving circuit with a single matched filter unit.

[0041] In order to solve the problems of the prior art described above, according to claim 2 of the invention, there is provided a CDMA receiving circuit for receiving a transmission signal transmitted from a base station with each frame including spread code information having long code information and user short code information and data information having a control signal/information signal, the spread code information and the data information being time-divided, the spread code information being directly spread by the base station short

code, the data information being directly spread by the spread code constituting the product of the long code and the user short code described in the spread code information, the CDMA receiving circuit comprising a receiving unit for down-converting the received signal from the carrier frequency band to the base band, a matched filter unit for acquiring the correlation between the received signal from the receiving unit and the input spread signal, a decision circuit for demodulating the data information from the output of the matched filter unit, a decoder for decoding the spread code information from the output of the matched filter unit, a switch for switching the destination of the output of the matched filter unit between the decision circuit and the decoder, a first spread code generator for sending out a base station short code, a second spread code generator for sending out the spread code constituting the product of the long code and the user short code based on the input spread code information, and spread code switching means for selecting one of the two types of spread codes from the first spread code generator and the second spread code generator and supplying the choice to the matched filter unit for controlling the switching operation of the switch, characterized in that when the decoder extracts the spread code information from the output of the matched filter unit, supplies it to the second spread code generator and outputs an instruction for switching the spread code to the spread code switching means, the spread code switching means selects the spread signal from the second spread code generator, supplies

it to the matched filter unit and controls the switch so the destination of the output of the matched filter unit is switched to the decoder, thereby making it possible to configure a CDMA receiving circuit with a single matched filter unit.

[0042] In order to solve the problem of the prior art described above, according to claim 3 of the invention, there is provided a CDMA receiving circuit according to claim 1 for receiving the signal of the data information transmitted by an adjacent base station using the same frequency and different long codes, characterized in that after complete initial capture of the spread code, the spread code information of the signal of the strongest average received power among the signals from other base stations than the one in communication is received and stored, and the correlation is determined based on the stored spread code information when the cell is moved, thereby making it possible to demodulate the received signal without interruption while eliminating the need of a dedicated matched filter unit for detecting the base station of an adjacent cell.

[0043] In order to solve the problem of the prior art described above, according to claim 4 of the present invention, there is provided a CDMA receiving circuit according to claim 2, characterized by the decoder for detecting the average received power of the signal received from each base station based on the output of the matched filter unit after initial capture, storing the averaged received power in the storage unit together with the short code for each base station and, at the time of moving to another cell, outputting the base station short

code of a base station having a large average received power stored in the storage unit as a spread code designating instruction to the first spread code generator, and the first spread code generator for sending out the the base station short code in accordance with the spread code designating instruction, thereby making it possible to demodulate the received signal without interruption while eliminating the need of a dedicated matched filter unit for detecting the base station of an adjacent cell.

[0044]

[Mode for Carrying out the Invention] Embodiments according to the claims of the present invention will be explained with reference to the drawings. In the first CDMA receiving circuit according to this invention, at the time of initial capture of the spread code immediately after power is switched on, the matched filter unit (MF unit) determines the correlation with the base station short code supplied from the first spread code generator, the long/short information (spread code information) is acquired by the decoder, and then, based on the long/short information acquired, the MF unit determines the correlation by use of the product of the user short code and the base station long code supplied from the second spread code generator, so that the decision circuit acquires the control signal/information signal (data information). Thus, the CDMA receiving circuit can be configured with a single MF unit, thereby making it possible to reduce both the circuit size and cost.

[0045] First, the configuration of the first CDMA receiving circuit according to the invention will be explained with reference to FIG. 1. FIG. 1 is a block diagram showing the configuration of the first CDMA receiving circuit according to the invention, in which the component parts having a similar configuration to the corresponding parts in FIG. 8 are designated by the same reference numerals, respectively.

[0046] The first CDMA receiving circuit according to the invention, as component parts similar to the conventional CDMA receiving circuit, comprises a RX 1, a first spread code generator 3, a decoder 4, a second spread code generator 5, an MF unit 6 and a decision circuit 7. Further, the invention is characterized by spread code switching means 8 and a switch 9.

[0047] Now, the component parts of the first CDMA receiving circuit will be explained specifically. The RX1, the first spread code generator 3, the second spread code generator 5 and the decision circuit 7 are exactly the same as the corresponding parts of the prior art, and therefore will not be described below.

[0048] The MF unit 6 is a matched filter (MF) for acquiring the correlation between the received baseband signal and the spread signal output from the spread code switching means 8 and outputs the correlation result to the switch 9.

[0049] The switch 9 switches the correlation result output from the MF unit 6 either (1) to the decoder 4 (a) or (2) to the decision circuit 7 (b), under the control of the spread code

switching means 8.

[0050] The decoder 4 acquires the long/short information transmitted from the base station like in the prior art, and applies the acquired long/short information to the second spread code generator 5 while instructing, as a feature of the invention, the spread code switching means 8 to switch the spread code.

[0051] Specifically, the decoder 4 is supplied with the correlation result output from the MF unit 6 through the switch 9, and upon acquisition of a high-level correlation value, outputs an instruction to the first spread code generator 3 to stop changing the base station short code thereby to specify the base station short code.

[0052] The long/short information transmitted by being spread by the specified base station short code is decoded. The long/short information is the spread code information including the current or the near-future base station long code information and the user short code information. The spread code information is output to the second spread code generator 5, while outputting, as a feature of the invention, an instruction to the spread code switching means 8 for switching the spread code.

[0053] The switch instruction is adapted to be output to the spread code switching means 8 each time the long/short code information (T1) in the received signal of FIG. 6 and the control signal/information signal (T2) are switched to each other.

[0054] Subsequently, the power value of the correlation result

output from the MF unit 6 is monitored, and upon occurrence of the requirement of a hand-off as the result of the power value decreasing below a preset value or otherwise, a change start instruction is output to the first spread code generator 3 to resume the change of the base station short code.

[0055] The spread code switching means 8 is for controlling the switching of the spread code applied to the MF unit 6 and the switching operation of the switch 9. Specifically, when power is thrown on, the spread code switching means 8 outputs the spread code of the base station short code to the MF unit 6 from the first spread code generator 3, and the switch 9 is connected to the decoder 4 side (a).

[0056] Upon receipt of a switching instruction from the decoder 4, the spread code switching means 8 switches the output to the MF unit 6 to the spread code making up the product of the user short code and the long code input from the second spread code generator 5, and further turns the switch 9 to the decision circuit 7 side (b).

[0057] After that, each time a switching instruction is received from the decoder 4, the output to the MF unit 6 is switched between the input from the second spread code generator 5 and the input from the first spread code generator 3, on the other hand, the switch 9 is turned between the decision circuit 7 side (b) and the decoder 4 side (a).

[0058] Now, the operation of the first CDMA receiving circuit according to the invention will be explained with reference to FIGS. 1 and 4. FIG. 4 is a diagram for explaining a specific

example of the cell concept of an ordinary CDMA. FIG. 4 shows each base station (BS1 to BS3) in each cell (cells 1 to 3) communicating with each mobile stations (MS11 to MS31).

[0059] The operation of initial synchronous capture of the spread code in the first CDMA receiving circuit according to the invention will be described with reference to a specific case in which the communication is newly started by the mobile station MS1x to the base station BS1 in the cell 1.

[0060] When power is switched on, the spread code switching means 8 in the CDMA receiving circuit of the mobile station MS1x so operates that the spread code output from the first spread code generator 3 is applied as a tap coefficient to the MF 6, and the switch 9 is set to (b) side so that the output of the MF 6 is input to the decoder 4.

[0061] Upon receipt of the signal having the format shown in FIG. 6 transmitted from the base station, the RX1 down-converts the frequency of the received signal from the carrier frequency band to the baseband as a baseband received signal, which is correlated by the MF 6 with the spread code supplied from the first spread code generator 3 through the spread code switching means 8.

[0062] At the same time, the first spread code generator 3 sequentially selects the base station short codes in frame periods from all the predetermined base station short codes, and the spread code of the selected base station short codes is output to the spread code switching means 8 and further to the MF unit 6.

[0063] In the MF 6, the baseband received signal is correlated with the spread code of the base station short code supplied from the spread code switching means 8, and the correlation is output to the decoder 4 through the switch 9.

[0064] The decoder 4, upon detection of the base station short code having a large average correlation value, outputs a change stop instruction to the first spread code generator 3 so that the spread code (base station short code) output from the first spread code generator 3 is fixed and specified. As a result, the base station short code of the base station BS1 is determined.

[0065] The signal transmitted from the base station is unique as shown in FIG. 6. In the case where the MF unit 6 continues to determine the correlation at least during one frame period, therefore, the spread code information including the user short code and the long code of the base station transmitted currently (or in the near future) from the base station can be extracted by the decoder 4.

[0066] The decoder 4 decodes the long/short code information from the result of correlating the base station short code, so that the spread code information including the long code information and the user short code information is acquired and output to the second spread code generator 5.

[0067] At the same time, a switch instruction is output from the decoder 4 to the spread code switching means 8, so that the spread code output to the MF unit 6 is switched to the spread code output from the second spread code generator 5 and the

switch 9 is turned to (b) side of the decision circuit 7.

[0068] The second spread code generator 5 produces the spread code constituting the product of the long code and the user short code based on the spread code information from the decoder 4, which spread code is output to the spread code switching means 8 and further to the MF unit 6, where the correlation with the received baseband signal is determined. The control signal/information signal is thus output through the switch 9 to the decision circuit 7 where it is demodulated.

[0069] As a result, upon complete initial synchronous capture of the spread code, each time the long/short code information (T1) and the control signal/information signal (T2) in the received signal are switched to each other, the switch instruction from the decoder 4 is output to the spread code switching means 8 thereby to switch between the output to the MF unit 6 and the switch 9. The operation at the time of hand-off in the first CDMA receiving circuit is similar to that of the conventional CDMA receiving circuit and therefore will not be described.

[0070] In the first CDMA receiving circuit according to the invention, at the time of initial capture of the spread code immediately after power is switched on, the MF unit 6 determines the correlation by the base station short code supplied from the first spread code generator 3, and the long/short information is acquired in the decoder 4. After that, based on the long/short information acquired, the MF unit 6 determines the correlation by the spread code constituting the product

of the user short code and the base station long code supplied from the second spread code generator 5, and the spread code supplied to the MF unit 6 and the switch 9 are switched to each other by the spread code switching means 8 in such a manner that the decision circuit 7 may acquire the control signal/information signal from the particular correlation result. Thus, the CDMA receiving circuit according to this invention can be constituted of a single MF unit, thereby making it possible to reduce both the circuit size and the cost.

[0071] Now, the second CDMA receiving circuit according to the invention will be explained. In the second CDMA receiving circuit according to the invention, upon complete initial capture of the spread code, the spread code information of the signal having the strongest average received power among the signals from the base stations other than the base station in communication is acquired and stored, and based on the spread code information stored, the correlation is determined when the cell is changed. Therefore, the received signal can be demodulated continuously and a smooth hand-off can be carried out without any special, dedicated matched filter unit for detecting the base station of an adjacent cell.

[0072] The configuration of the second CDMA receiving circuit according to the invention will be explained with reference to FIG. 2. FIG. 2 is a block diagram showing a configuration of the second CDMA receiving circuit according to the invention. The component parts having the same configuration as the corresponding parts in FIG. 1 will be described with the same

reference numerals attached thereto.

[0073] The second CDMA receiving circuit according to the invention, basically similar to the first CDMA receiving circuit, comprises a storage unit 10 as a feature thereof. Also, the operation of the first spread code generator 3' and the decoder 4' of the second CDMA receiving circuit is somewhat different from that of the first CDMA receiving circuit.

[0074] Now, each part of the second CDMA receiving circuit will be specifically explained. Only those parts which are different from the corresponding parts of the first CDMA receiving circuit will be explained. The storage unit 10 is for storing the average received power of the signal from the base stations other than the base station in communication with the CDMA receiving circuit, together with the number of the base station short code of the particular base station.

[0075] Specifically, the storage unit 10 has stored therein, as shown in FIG. 3, the numbers of the base station short code preset in the first spread code generator 3 and the corresponding average received power values in descending order with the opposite order of the corresponding addresses. FIG. 3 is a diagram for explaining an internal configuration example of the storage unit 10 of the second CDMA receiving circuit according to the invention. By the way, the storage unit 10 may be built in the decoder 4'.

[0076] The decoder 4', like the decoder 4 of the first CDMA receiving circuit, acquires the long/short information transmitted from the base station, applies the long/short

information thus received to the second spread code generator 5, instructs the spread code switching means 8 to switch the spread code, and as a feature of the second CDMA receiving circuit, monitors the average received power of the radio wave from each base station thereby to control the operation at the time of hand-off.

[0077] Specifically, the decoder 4' initially captures the spread code with a similar operation to the decoder 4 of the first CDMA receiving circuit, and after complete initial capture, constantly monitors the average received power of the ratio wave from each station, and stores the average received power of the radio wave from the base stations other than the base station in communication in the storage unit 10 in the descending order.

[0078] In the case where the average received power of the radio wave from the base station in communication decreases below a preset value or otherwise the need arises for hand-off, the spread code numbers stored in the storage unit 10 are output to the first spread code generator 3' in the descending order of power value, and the base station short codes output from the first spread code generator 3' are switched immediately to a base station having a larger average received power. In the case where the long/short information cannot be obtained due to the change in the transmission path or the like, the spread code number of the next largest power value is output to the first spread code generator 3'.

[0079] Assume that the long/short information is obtained with

a new base station short code, the spread code of the destination base station with a similar operation to the initial capture is captured, and the hand-off is accomplished. Then, the change start instruction is issued to the first spread code generator 3'.

[0080] The operation of the first spread code generator 3' at the time of initial capture immediately after power is thrown in is similar to that of the first spread code generator 3 of the conventional first CDMA receiving circuit. The additional feature of the second CDMA receiving circuit is that when the spread code designating instruction is received from the decoder 4', the spread code of the base station short code of the particular spread code number is output to the MF unit 2.

[0081] Now, the operation of the second CDMA receiving circuit according to the invention will be explained with reference to FIG. 4. The operation at the initial capture of the second CDMA receiving circuit is similar to that of the first CDMA receiving circuit and will not be described, but only the operation at the time of hand-off will be explained.

[0082] Suppose that the mobile station MS11 moves to the adjacent cell 2 in FIG. 4. The CDMA receiving circuit of the mobile station MS11 is connected already to the base station BS1 in the cell 1, and therefore the spread code including the long code and the user short code is output from the second spread code generator 5 and through the spread code switching means 8 applied to the MF unit 6.

[0083] In response to a switch instruction from the decoder

4', the spread code switching means 8 switches the output to the MF unit 6 and the switch 9 to each other. Further, a change start instruction instruction is output from the decoder 4' to the first spread code generator 3', and the base station short codes output from the first spread code generator 3' are sequentially changed, so that the long/short information portion (T1) of the signal transmitted from each of the base stations BS1 to BSn (n: number of base station short codes) is output to the decoder 4'.

[0084] Then, in the decoder 4', the average received power of the signals transmitted from the base stations is monitored, and the average received power values of the base stations other than the one in communication are stored in the storage unit 10 in the descending order together with the base station spread numbers.

[0085] In the decoder 4', on the other hand, the average received power of the base station (BS1) in communication is monitored, and when it decreases below a preset value, the spread code numbers associated with the average received power stored in the storage unit 10 are output in the descending order of the latter to the first spread code generator 3' as spread code designating instructions. Then, the base station short code of the designated spread code number is output from the first spread code generator 3' to the spread code switching means 8, and after the correlation is determined by the MF 6, output to the decoder 4' through the switch 9.

[0086] Then, the decoder 4' produces the long code information

of the base station and available user short code information from the long/short code information shown in FIG. 6. In other words, before the cell boundary is crossed, the spread code information (the long code and the user short code) of the destination is determined. Thus, no special, dedicated MF unit is required for detecting the base station of the adjacent cell, thus making it possible to accomplish the hand-off smoothly.

[0087] The transition of the output of the MF unit 6 and a specific received radio wave at the time of hand-off will be explained with reference to FIG. 5. FIGS. 5(A) to (E) show an example of the time chart of the received radio wave and the output of the MF unit 6 at the time of hand-off. Also, the MF unit is assumed to be the one for the spread code, and the arrows in the drawing indicate the display of one symbol of the signal.

[1088] First, assume that the mobile station MS1 shown in FIG. 4 is in communication with the base station BS1 and the receiving level is sufficient for demodulation. Specifically, as shown in FIG. 5(A), assume that the received power level (envelope) is large initially, and the output of the MF unit 6 shown in FIG. 5(B) also initially meets the required level.

[0089] The impulse response of the transmission path from the BS1 assumes a model having two conspicuous echoes. The MS11 moves toward the adjacent cell 2, and therefore, the received power level from BS1 of FIG. 5(A) decreases with time. Thus, at about the intermediate point of FIGS. 5(A), 5(B), the received signal level from BS1 becomes insufficient, and the connecting base station is required to be changed.

[0090] In the process, as shown in FIGS. 5(C), 5(D), assume that the received signal from BS2 of the adjacent cell 2 has reached a required level. The mobile station terminal MS11 changes the connection to BS2 of the cell 2 (In FIG. 5(D), the transmission path from BS2 assumes an impulse response with one echo).

[0091] The conventional TDMA cellular system requires the change of frequency when changing the base station, and an instantaneous interruption occurs at the time of frequency change. In CDMA, on the other hand, adjacent base stations transmit the same information at the same frequency and therefore the instantaneous interruption is not caused when the frequency is switched.

[0092] The remaining problem is how to know the long code information and the available user short code of the base station BS2 for changing the connection to the base station 2. The adjacent cell is recognized, as described above, by measuring the received signal power from the adjacent cell transmitted from the base station for each frame. Therefore, the received power of the adjacent cells can be recognized at every several frames (number of adjacent cells multiplied by frame period).

[0093] As a result, the receiving can be switched seamlessly from the received signal of BS1 which has decreased in level to the received signal of BS2.

[0094] In the second CDMA receiving circuit according to the invention, after complete initial capture of the spread code,

the decoder 4' detects the average received power of the signals from the base stations other than the base station in communication, stores them in the storage unit 10 in the descending order of strength together with the spread code numbers, and when the cell is changed, the correlation is determined based on the spread code numbers stored. Therefore, no special dedicated MF unit is required for detecting the base station of the adjacent cell, but the received signals can be demodulated without interruption, thus realizing smooth hand-off.

[0095] Especially, the hand-off by the mobile station moving at high speed between base stations having a narrow area (microcell, picocell, etc. for example) can be sufficiently accomplished.

[0096]

[Effects of the Invention] According to the invention described in claim 1, there is provided a CDMA receiving circuit comprising a matched filter unit in which at the time of initial capture of the spread code immediately after power is switched on, the correlation is determined between the received signal and the base station short code thereby to acquire the spread code information, after which the spread code is input while being switched in such a manner as to acquire the data information by determining the correlation between the received signal and the spread code representing the product of the user short code and the long code based on the acquired spread code information. In this way, the CDMA receiving

circuit can be constituted of a single matched filter unit, thus making it possible to reduce both the circuit size and the cost.

[0097] According to the invention described in claim 2, there is provided a CDMA receiving circuit in which at the time of initial capture of the spread code immediately after power is switched on, the base station short code is input to the matched filter unit by the switching operation of the spread code switching means from the first spread code generator, the correlation is determined by the matched filter unit with the base station short code and output to the decoder by the operation of the switch, and the spread code information is acquired by the decoder, after which based on the spread code information acquired, the spread code constituted of the product of the long code and the user short code is input to the matched filter from the second spread code generator by the operation of the spread code switching means, the correlation is determined by the matched filter unit with the particular spread code and output to the decision circuit by the operation of the switch, and the decision circuit acquires the data information. Thus, the CDMA receiving circuit can be configured with a single matched filter unit, thereby making it possible to reduce both the circuit size and cost.

[0098] According to the invention described in claim 3, there is provided a CDMA receiving circuit in which after complete initial capture of the spread code, the spread code information of the signal having the strongest average received power among

the signals received from the base stations other than the one in communication is acquired and stored, and in the case where the cell is changed, the correlation is determined based on the spread code information stored, and therefore the received signal can be demodulated without interruption and the hand-off can be accomplished smoothly without any special, dedicated matched filter unit for detecting the base station of an adjacent cell.

[0099] According to the invention described in claim 4, there is provided a CDMA receiving circuit in which after complete initial capture, the average received power of the signals received from each base station is detected from the output of the matched filter unit and stored in the storage unit internal or external to the decoder together with the base station short code of the base stations, and in the case where the cell is changed, the base station short code of the base station having a large average received power stored is output by the decoder to the first spread code generator as a spread code designating instruction, and the first spread code generator sends out the base station short code in compliance with the spread code designating instruction. Therefore, the received signal can be demodulated without interruption and the hand-off can be accomplished smoothly without any special, dedicated matched filter unit for detecting the base station of an adjacent cell.

[Brief Description of the Drawings]

[FIG. 1] A block diagram showing a configuration of a first

CDMA receiving circuit according to the present invention.

[FIG. 2] A block diagram showing a configuration of a second CDMA receiving circuit according to the present invention.

[FIG. 3] A diagram for explaining an example of an internal configuration of the storage unit of the second CDMA receiving circuit according to the invention.

[FIG. 4] A diagram showing a specific example of the general concept of the cell of an ordinary CDMA.

[FIG. 5] A diagram showing an example of the time chart of the received radio wave and the output of the MF unit 6 at the time of hand-off.

[FIG. 6] A diagram showing the format in an example of a frame configuration of the transmission signal from each base station to each mobile station in the same cell.

[FIG. 7] A diagram for explaining the relationship between an example of the M series generating polynomial and the contents of the shift register.

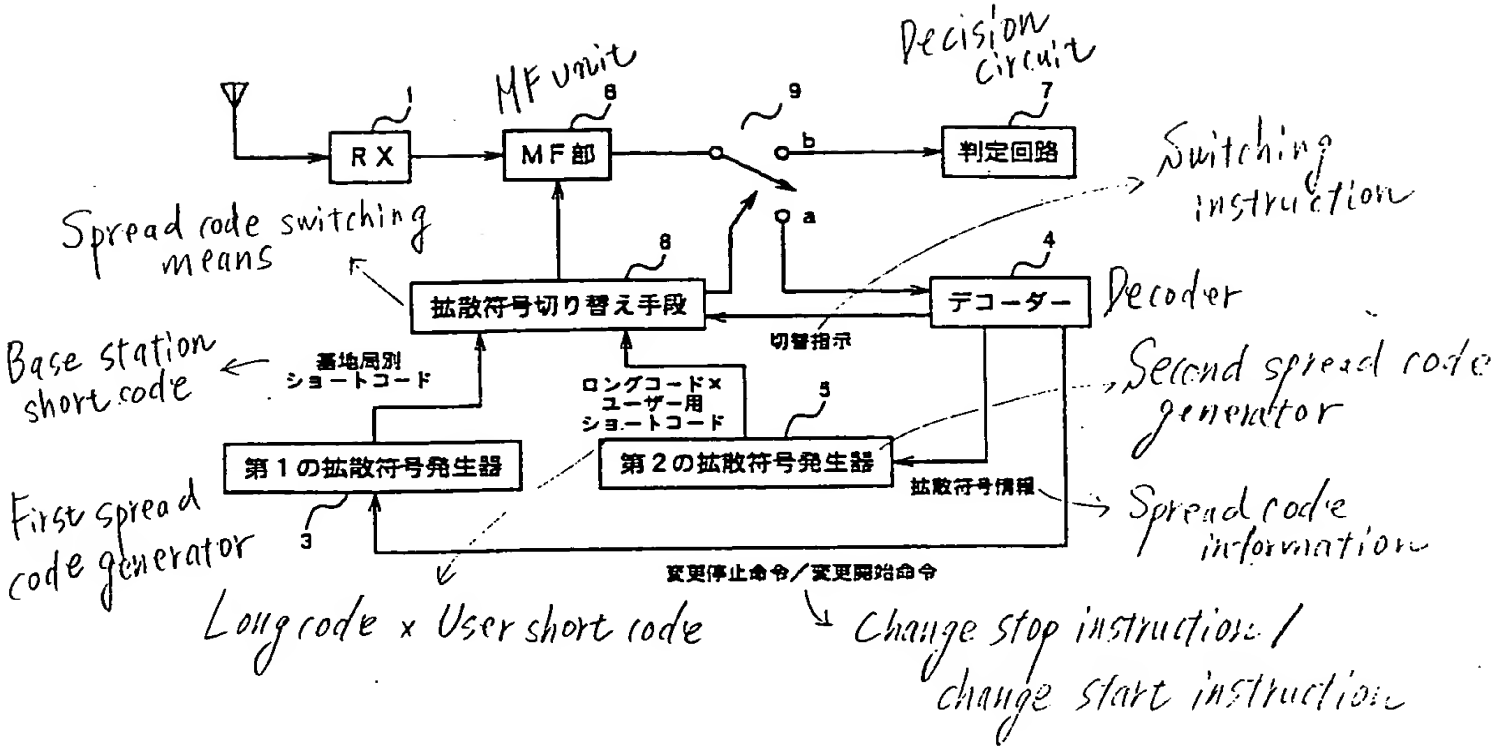
[FIG. 8] A block diagram showing a configuration of the conventional CDMA receiving circuit.

[Description of Reference Numeral]

1...RX, 2, 6, 6"...MF unit, 3, 3'...First spread code generator, 4, 4', 4"...Decoder, 5...Second spread code generator, 7...Decision circuit, 8...Spread code switching means, 9...Switch, 10...Storage unit.

FIG.1

【図1】



【図3】

FIG.3

アドレス	電力値	拡散符号番号
0	100	PN1
1	70	PN5
2	50	PN3
3	40	PN4
・	・	・
・	・	・

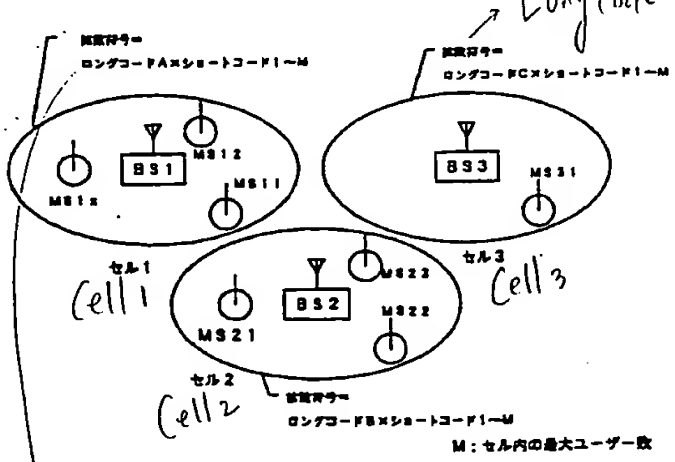
Address

Power value

Spread code number

【図4】

FIG.4



Spread code = Long code C × Short code 1 to M

Spread code = Long code A × Short code 1 to M

Spread code = Long code B × Short code 1 to M

M: maximum number of users in cell

FIG. 2

【図2】

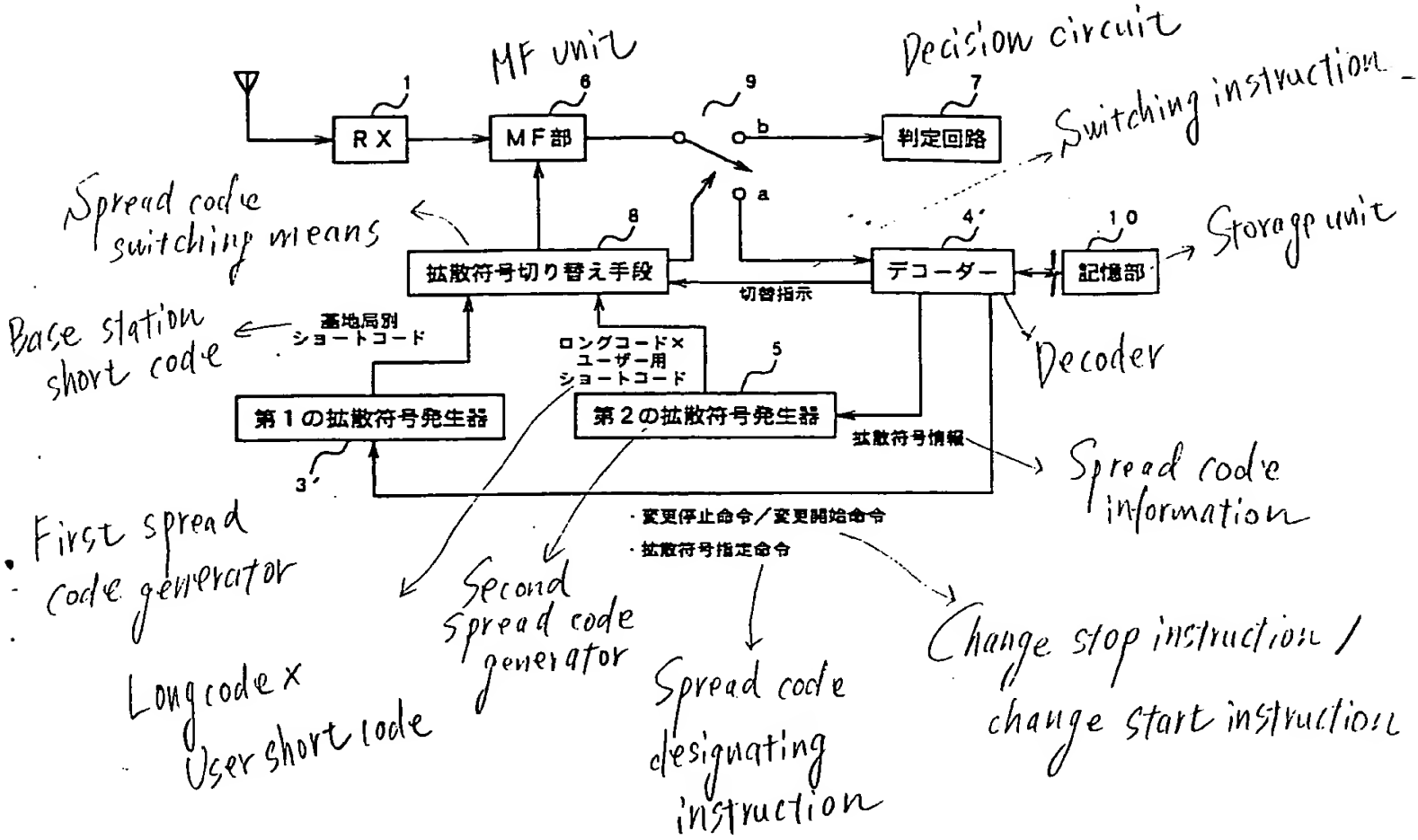
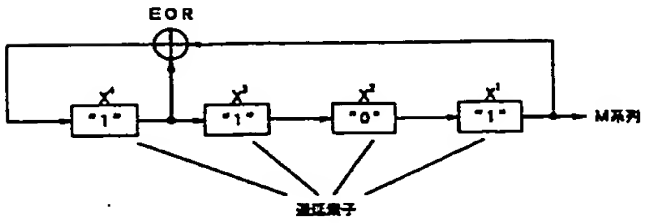


FIG. 7

【図7】

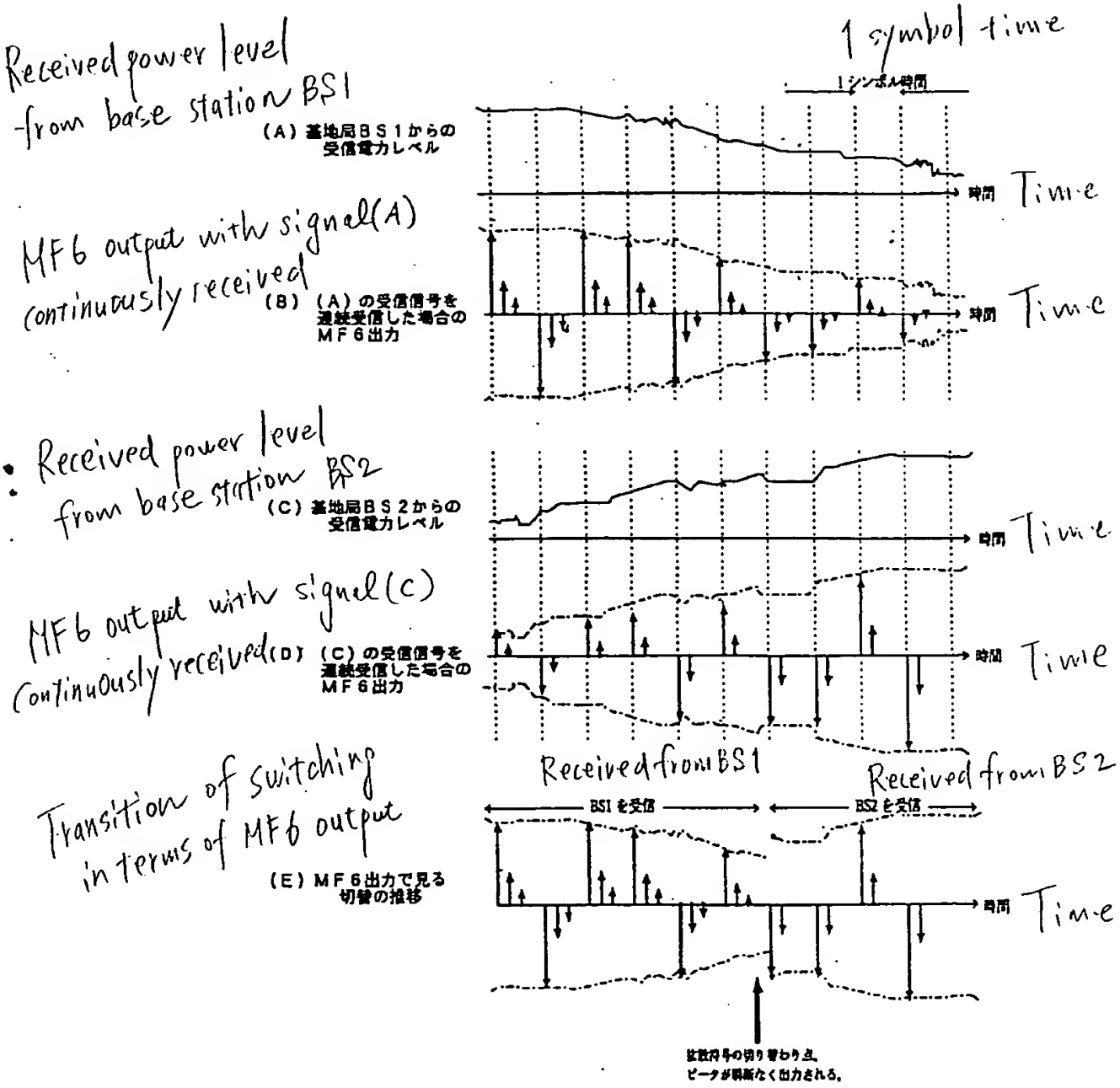


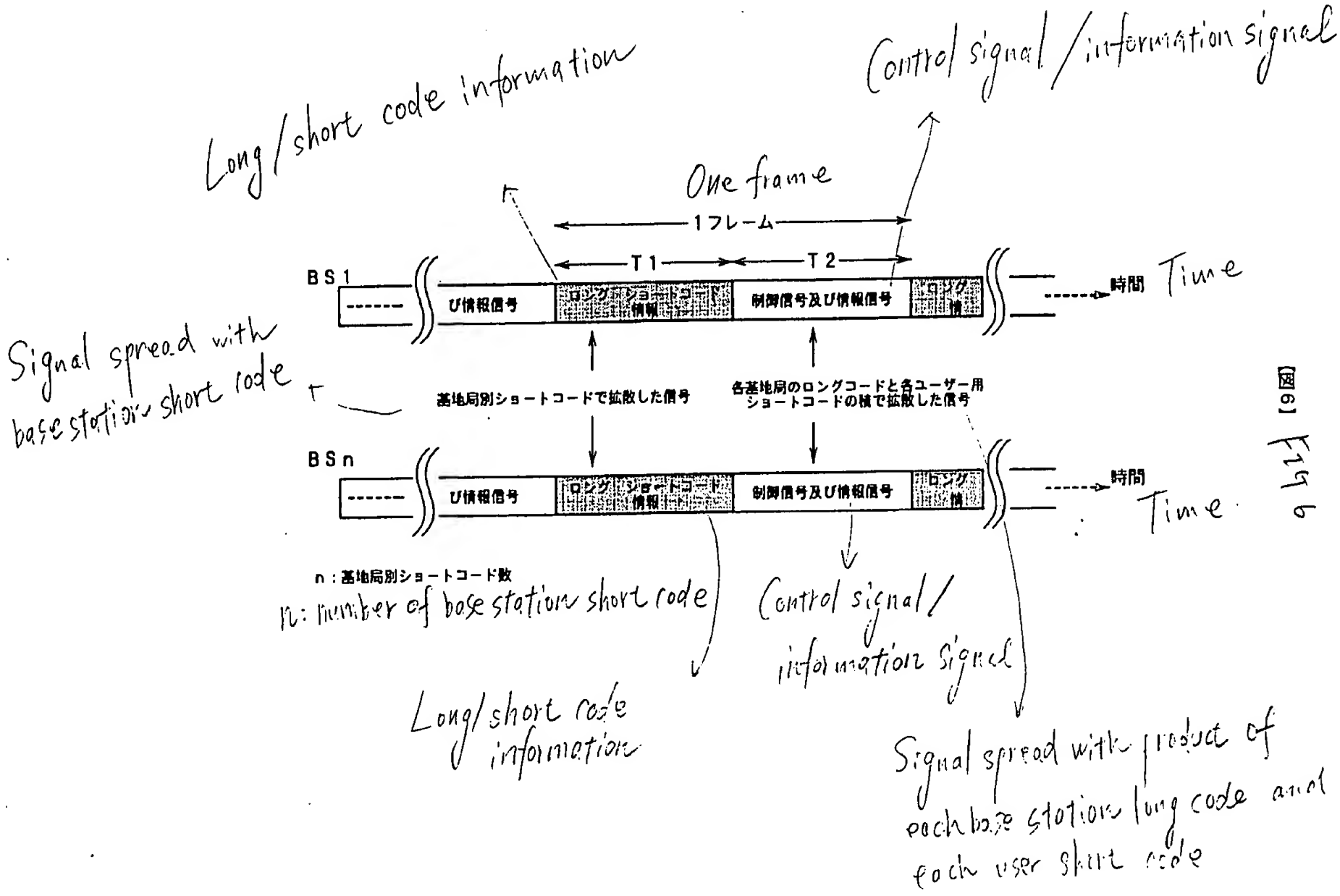
M series

Delay element

【図5】

FIG. 5

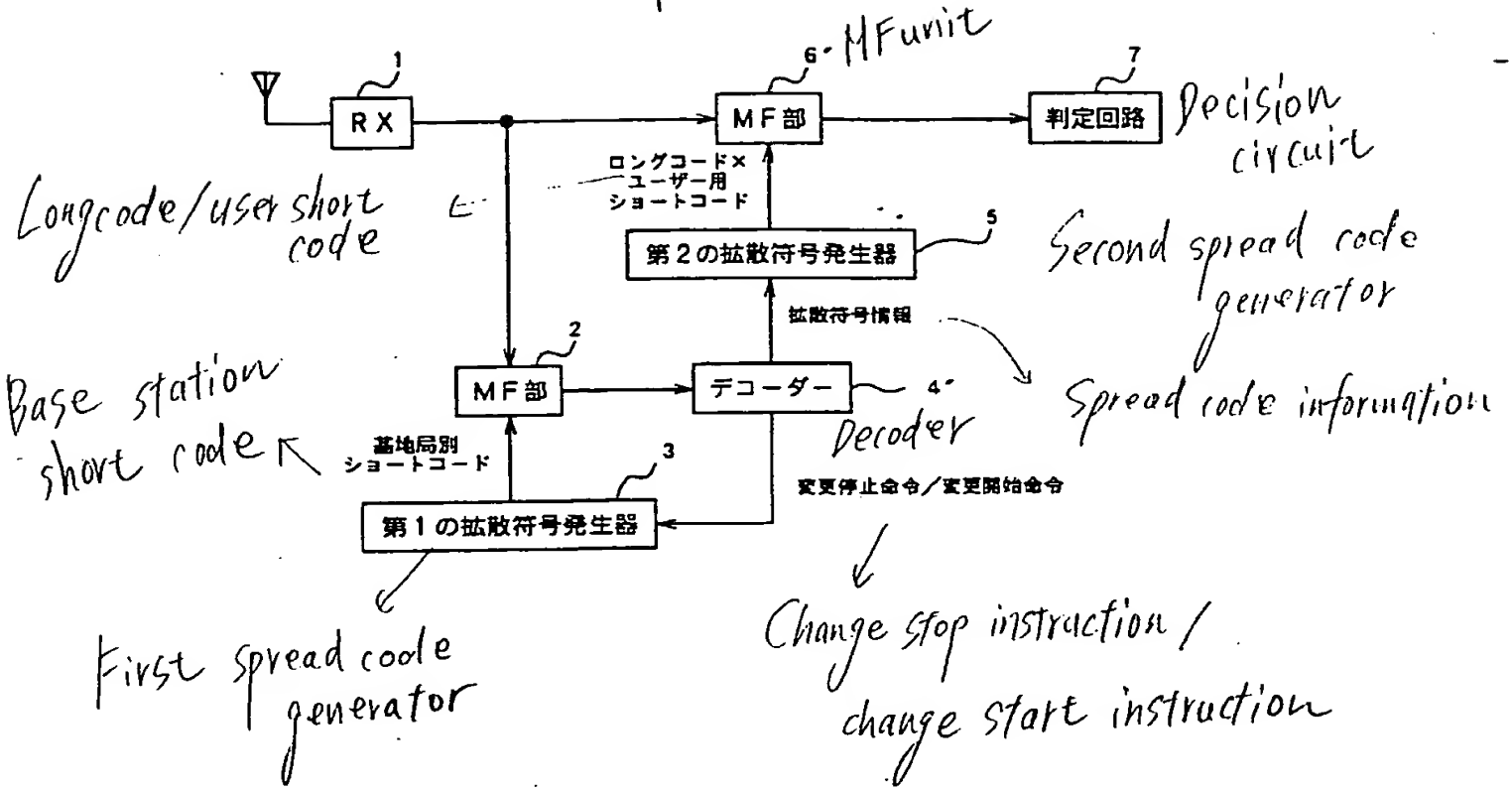

Received power level from base station BS1
(A) 基地局ＢＳ１からの受信電力レベル
1 symbol time
1シンボル時間
時間
Time
MF6 output with signal(A) continuously received
(B) (A)の受信信号を連続受信した場合のＭＦ６出力
時間
Time
Received power level from base station BS2
(C) 基地局ＢＳ２からの受信電力レベル
時間
Time
MF6 output with signal(C) continuously received
(D) (C)の受信信号を連続受信した場合のＭＦ６出力
時間
Time
Received from BS1
Received from BS2
Transition of switching in terms of MF6 output
(E) ＭＦ６出力で見る切替の推移
BS1を受信
BS2を受信
時間
Time
拡散符号の切り替わり点、ピークが瞬断なく出力される。
Spread code switch point
Peaks output without interruption


Long/short code information
Control signal / information signal
One frame
1フレーム
T1
T2
BS1
び情報信号
ロング ショートコード 情報
制御信号及び情報信号
ロング 情
時間
Time
Signal spread with base station short code
基地局別ショートコードで拡散した信号
各基地局のロングコードと各ユーザー用ショートコードの積で拡散した信号
BSn
び情報信号
ロング ショートコード 情報
制御信号及び情報信号
ロング 情
時間
Time
n：基地局別ショートコード数
n: number of base station short code
Long/short code information
Control signal/ information signal
Signal spread with product of each base station long code and each user short code

[図6] Fig 6

【図8】

FIG. 8



MFunit

Decision circuit

Longcode/user short code

Second spread code generator

Spread code information

Base station short code

Decoder

First spread code generator

Change stop instruction / change start instruction